

April 28, 1959

C. E. STAPLES

2,884,516

PHASE SENSITIVE ALTERNATING CURRENT TRACK CIRCUIT

Filed Sept. 21, 1956

5 Sheets-Sheet 1

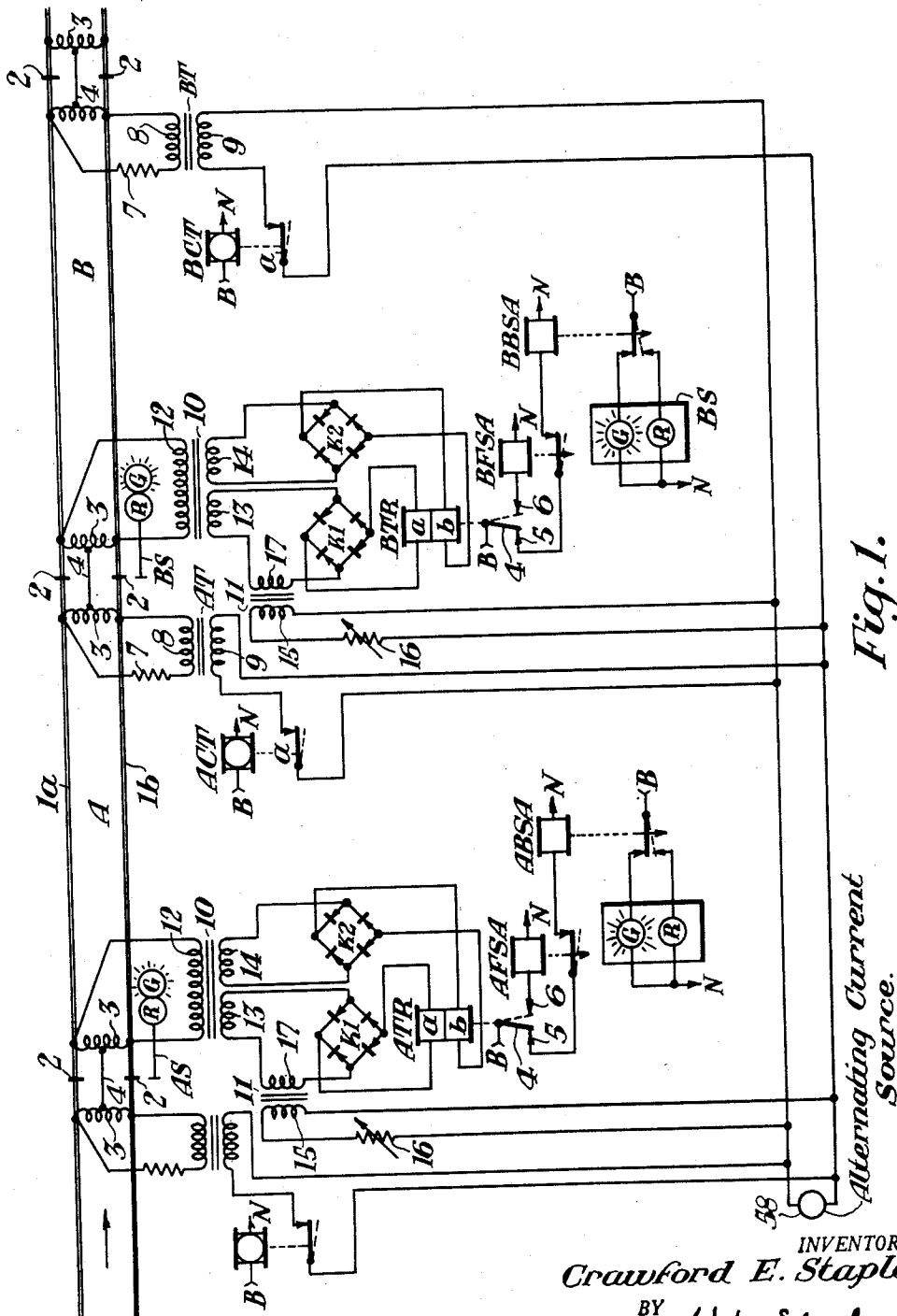


Fig. 1.

Alternating Current Source.

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5 Sheets-Sheet 2

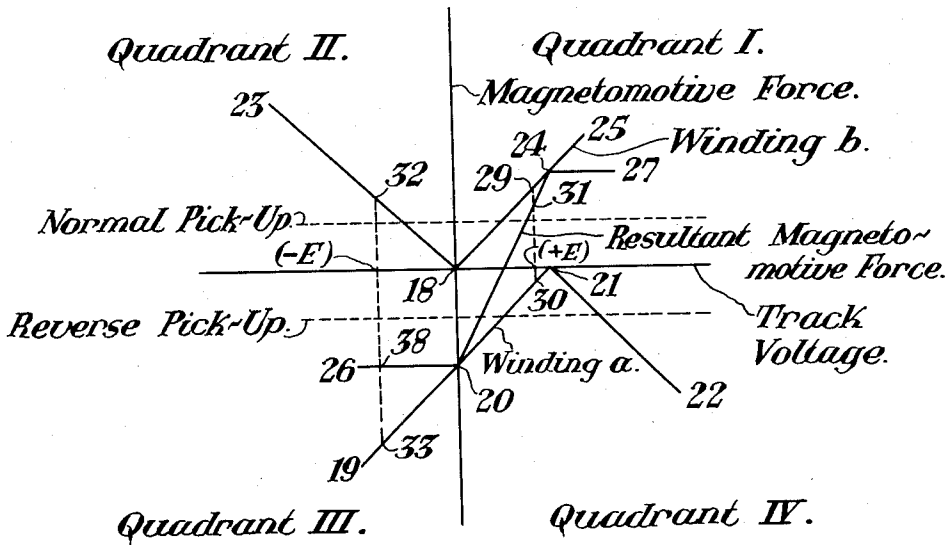


Fig. 2.

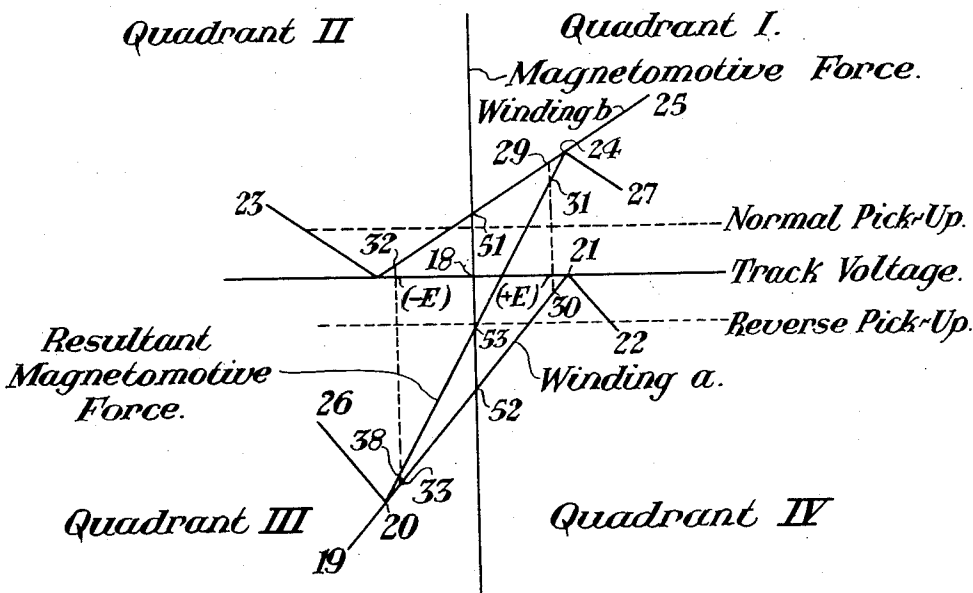


Fig. 5.

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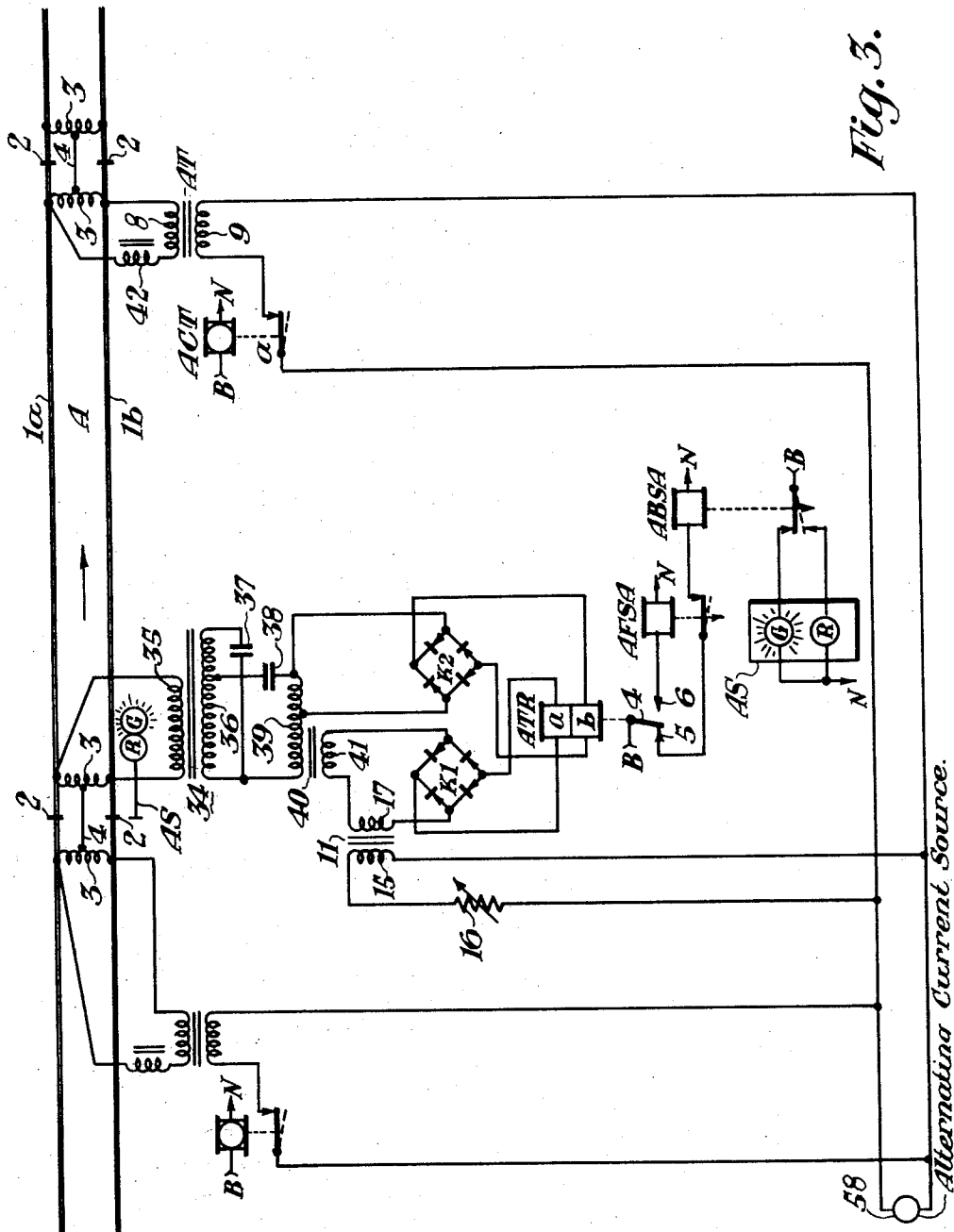
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5 Sheets-Sheet 3



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5 Sheets-Sheet 4

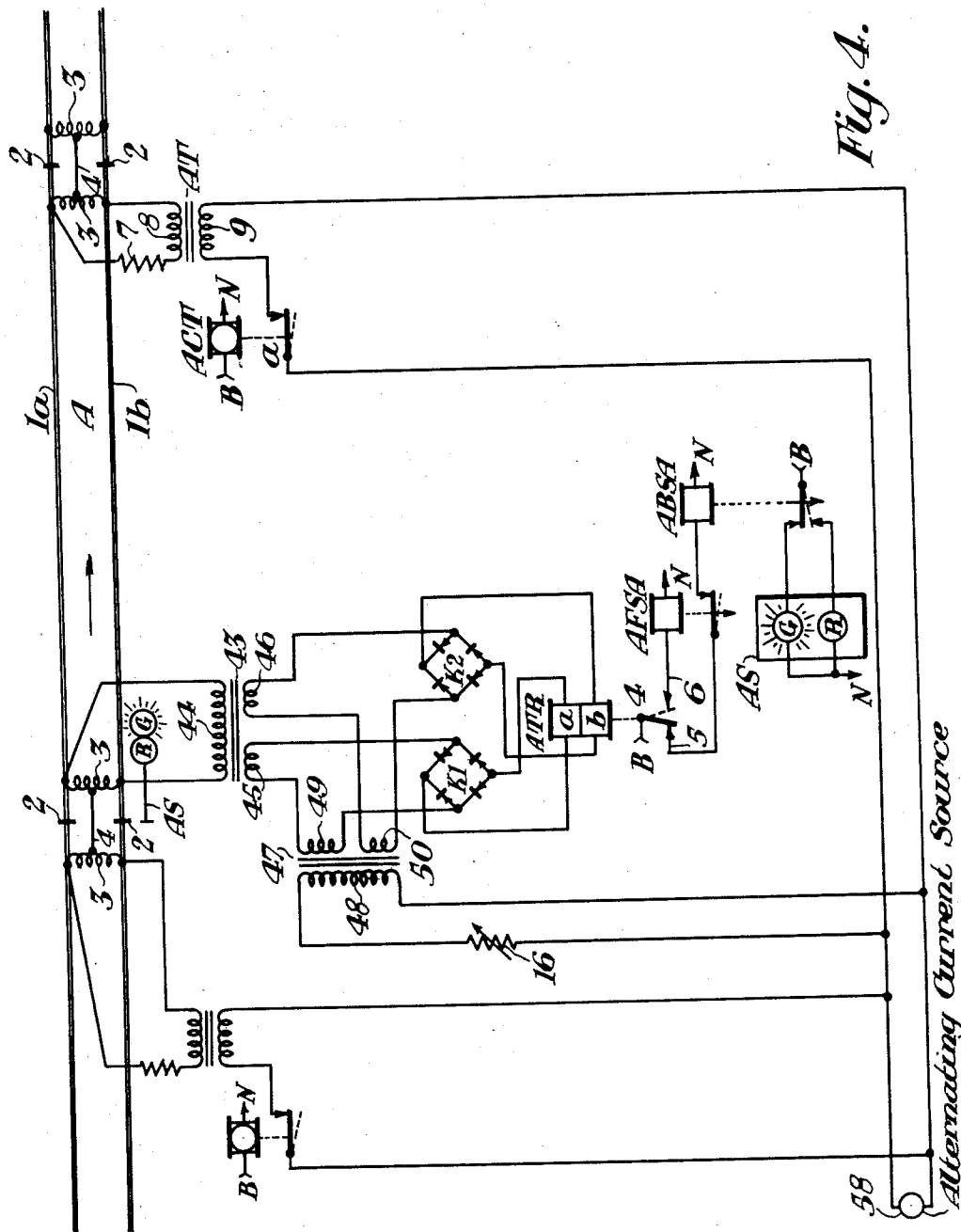


Fig. 4.

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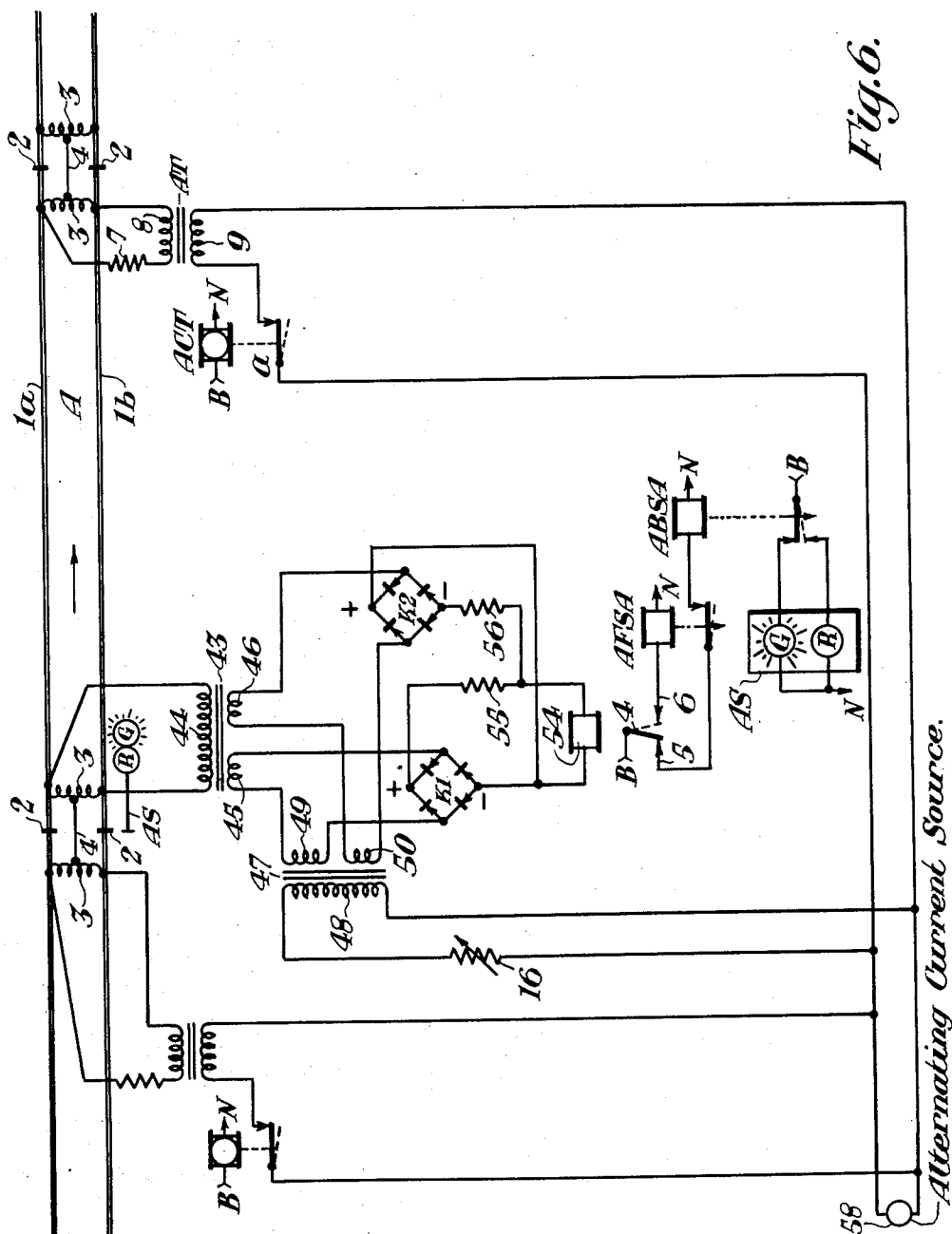
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PHASE SENSITIVE ALTERNATING CURRENT TRACK CIRCUIT

Filed Sept. 21, 1956

5 Sheets-Sheet 5



Current Source.	Current	Source.
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
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8	8	8
9	9	9
10	10	10
11	11	11
12	12	12
13	13	13
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92	92	92
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99	99	99
100	100	100

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PHASE SENSITIVE ALTERNATING CURRENT TRACK CIRCUIT

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Application September 21, 1956, Serial No. 611,330

5 Claims. (Cl. 246—34)

My invention relates to a phase sensitive alternating current track circuit for use in connection with railway signaling systems. More particularly, my invention relates to an improvement upon the track circuit shown and described in Letters Patent of the United States No. 2,585,505, issued February 12, 1952, to D. G. Shipp.

One of the problems encountered in the use of alternating current track circuits in connection with railway signaling systems is that of preventing improper operation of the track signals associated with the signaling system, due to currents feeding across defective insulated rail joints. The failure of such insulated rail joints is particularly dangerous in signaling systems in which the track sections are separated by insulated joints in one rail only or in systems in which the sections are separated by insulated joints in both rails and with adjoining track sections connected with impedance bonds, the impedance bonds providing a return path for traction current in electrified railway territory. In either case, the failure of a single insulated rail joint might permit the full track voltage of an adjoining track section to feed across a defective insulated joint and the impedance bond to cause improper operation of the track signals.

Previously, protection against such effects has been provided by supplying adjoining track sections with alternating currents of opposite relative polarity and interposing phase sensitive apparatus between the track rails and the track relay associated with the track section, as shown in the above mentioned patent. However, such track circuits have been found to be undesirable since certain defective components within the phase sensitive apparatus along with a defective insulated rail joint may also result in the improper operation of the track signals.

It is, therefore, an object of the present invention to overcome the above mentioned difficulty.

A further object is to provide the track circuits associated with a railway signaling system with phase sensitive apparatus wherein the track signals are irresponsive to the flow of current from adjoining track sections across a defective insulated rail joint even when components within the phase sensitive apparatus are defective.

In accordance with my invention, I provide one end of each track section with coded alternating current energy, and adjoining track sections are provided with currents of opposite relative polarity. The opposite end of each track section is provided with a direct current relay which is connected to the track rails through phase sensitive apparatus. The phase sensitiveness is achieved through an unique arrangement whereby the track relay is responsive only to currents applied to the track rails having a predetermined relative polarity and is irresponsive to currents of any polarity applied to the track rails when a component within the phase sensitive apparatus is defective.

Other objects of my invention will appear hereinafter as the characteristic features of construction and mode of operation of the apparatus embodying my invention are considered in detail.

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I shall first describe several embodiments of my invention and shall then point out the novel features thereof in claims.

In the accompanying drawings,

Fig. 1 is a diagrammatic view showing one form of phase sensitive track circuit embodying my invention employed in connection with a railway signaling system.

Fig. 2 is a diagrammatic representation of the operation of the phase sensitive track circuit shown in Fig. 1 whereby improper operation of the track signals is prevented.

Fig. 3 is a diagrammatic view showing a track circuit embodying my invention provided with a filter circuit for reducing the effect of foreign currents flowing in the track rails.

Fig. 4 is a diagrammatic view of a track circuit embodying my invention provided with a second form of phase sensitive apparatus.

Fig. 5 is a diagrammatic representation of the operation of the phase sensitive apparatus employed in the track circuit of Fig. 4.

Fig. 6 is a diagrammatic view of a track circuit embodying my invention illustrating the manner in which a single winding track relay may be employed in connection with my invention.

In each of the different views similar reference characters are used to designate similar parts.

Referring now to Fig. 1, there is shown a stretch of railway track comprising track rails 1a and 1b. The stretch of track is divided into track sections, two of which are designated by the reference characters A and B. The track rails of adjoining track sections are separated by insulated rail joints 2 and adjoining sections are electrically connected by means of impedance bonds. The impedance bonds comprise center tapped inductances 3 which are connected across the track rails at the ends of each section. The center taps of the inductances of adjoining track sections are conductively connected by means of a conductor 4 to provide a return path for traction current.

Traffic normally moves through the stretch of track in the direction indicated by the arrow, that is from left to right, and the movement of traffic into each track section is controlled by a suitable signal, designated by the reference character S with a prefix corresponding to the track section with which it is associated, located adjacent the entrance end of the track section. As shown, the signals are of the color light type, and each is provided with a red or stop lamp R and a green or proceed lamp G.

Each track section is provided with a track relay located adjacent the entrance end of the track section and designated by the reference character TR with a prefix corresponding to the reference character for the track section with which it is associated.

The track relays are code following relays of the magnetic stick type and may be equipped with a single winding having a center tap or as here shown with two separate windings comprising coils a and b. The relays are further provided with a movable member 4 which cooperates with fixed contacts 5 and 6 in a manner so that, when the relay is energized in a manner soon to be explained, a circuit is alternately completed to each of these contacts. The track relay controls slow releasing code detecting relays designated by the reference characters FSA and BSA with a prefix corresponding to the track section with which they are associated in such manner that the relay BSA is energized when, and only when, the associated track relay is responding to coded energy. The relay BSA controls the track signals so that the red or stop lamp is lighted when the relay BSA is released and a green or proceed lamp is lighted when the relay

BSA is energized. Each track relay is connected to the track rails through a phase sensitive apparatus, the operation of which will soon be explained.

A source of alternating current energy coded at a suitable code rate for operating the track relay is connected to the opposite end of each track section through a transformer designated by the reference character T with a prefix corresponding to the track section with which it is associated. A current limiting device 7, here shown as a resistance, is connected in series with a secondary winding 8 of the transformer and the track rails to limit the flow of current through the transformer at times when the track rails are shunted by the wheels and axles of a vehicle within the track section. A primary winding 9 of the transformer is connected through contact *a* of a code transmitter, designated by the reference character CT with a prefix corresponding to the track section with which it is associated, to a source of alternating current energy 58. The circuit connections between the source of current and the transformers of adjoining track sections are arranged so that the currents supplied to adjoining track sections are of opposite relative polarity. The code transmitters cause the track sections to be supplied with alternating current energy which is periodically interrupted at a suitable code rate for operating the track relay.

To prevent the track relay and associated track signals from being operated improperly due to current flowing across a defective insulated rail joint separating two adjacent track sections, phase sensitive apparatus is interposed between the track relay and the track rails. This arrangement provides means for comparing the relative polarity of the current received at the relay end of the track section with current having a predetermined relative polarity. If the currents received at the relay end of the track section have the predetermined relative polarity, the track relay is responsive, but if the received current is of opposite relative polarity the track relay is irresponsive. This makes it possible to assure that the track relay is not responding to current from an adjoining track section due to a defective insulated joint which would cause improper operation of the track signals.

The phase sensitive apparatus comprises a track transformer 10, an auxiliary transformer 11, and a first and second rectifier designated by the reference characters K1 and K2 respectively. Each track transformer is provided with a pair of secondary windings 13 and 14 and with a primary winding 12 which is connected to the track rails. The auxiliary transformer is provided with a primary winding 15 which is, preferably, connected through a phase shifting device 16 to the source which supplies alternating current to the track rails or to a source having a fixed phase relationship with that source. The phase shifting device provides means for adjusting the phase of the current flowing in the primary winding and is here shown as variable resistance 16. The auxiliary transformer is provided with a secondary winding 17 which is connected, in a series opposing relationship with the secondary winding 13 of the track transformer 10, to the rectifier K1. The phase shifting device 16 provides means for adjusting the relative phase of the voltages induced in the secondary winding 17 of transformer 11 so that this voltage and the voltage induced in winding 13 of transformer 10 are substantially 180° out of phase. This phase shift compensates for the phase shift of the track current due to the impedance of the track circuit. Winding 14 of transformer 10 is connected to rectifier K2. The direct current terminals of rectifiers K1 and K2 are connected to windings *a* and *b*, respectively, of the track relay. Although the rectifiers are here shown connected in a bridge arrangement, it is to be understood that other forms of rectifying circuits such, for example, as a single half wave rectifier may be employed.

To provide an understanding of the mode of opera-

tion of the phase sensitive apparatus, reference is made to Fig. 2. There shown is a set of mutually perpendicular axes, hereinafter referred to as the abscissa and ordinate axes intersecting at a point to provide a four quadrant representation of the operation and which quadrants intersect at a common point referred to as an origin and represented by the reference character 18. The abscissa axis represents the track voltage applied to winding 12 of the track transformer 10. Voltages to the right of the origin represent track voltages having a definite phase relationship with the voltage induced in the secondary winding 17 of transformer 11, hereinafter referred to as the normal phase, and voltages to the left of the origin represent track voltages of the opposite relative phase relationship and, hereinafter referred to as the reverse phase. Similarly, the ordinate axis represents the magnetomotive force produced by the windings of the track relay as a result of the track voltage. Magnetomotive forces above the origin represent magnetomotive forces produced by the relay windings in one direction, hereinafter referred to as the normal or positive magnetomotive force, and magnetomotive forces below the origin represent magnetomotive forces produced by the relay windings in the opposite direction, hereinafter referred to as the reverse or negative magnetomotive force.

The voltages induced in winding 13 of transformer 10 and winding 17 of transformer 11 cause a magnetizing force to be developed in winding *a* of the track relay ATR. This magnetizing force is represented in Fig. 2 by a discontinuous line designated by 19—20—21—22 which lies within quadrants III and IV. Similarly, the voltages induced in winding 14 of transformer 10 provides a magnetizing force for winding *b* of the track relay which is represented by the discontinuous line 23—18—24—25 which lies within quadrants I and II. These magnetizing forces combine in a vectorial relationship to provide a resultant flux; that is, the magnetizing forces produce fluxes in opposite directions within the relay core which oppose each other. The resulting flux within the core is represented on the diagram by a discontinuous line 26—20—24—27 which lies within quadrants I, III and IV.

The armature of the track relay is moved to the normal position when, and only when, the resulting magnetomotive force produced by the relay windings exceeds, in a positive direction, a magnetomotive force represented by a broken line labeled "normal pick-up." Similarly, the armature is moved to the reverse position when, and only when, the magnetizing force exceeds, in a negative direction, that represented by a dotted line labeled "reverse pick-up." Accordingly, if the relay is to follow code, it is necessary that the relay be alternately energized with positive and negative magnetizing forces which are equal to or exceed the normal pick-up and reverse pick-up values respectively. It is this feature which is responsible for the apparatus of my invention being immune to currents feeding across defective insulated rail joints to operate the track signals improperly, as discussed below, even when parts are defective within the phase sensitive apparatus.

I shall presently describe the normal operation of the apparatus associated with track section A in Fig. 1 and shall, thereafter, describe the behavior of the circuit in response to a defective insulated rail joint.

At times when contact *a* of the code transmitter ACT is open, there is no energy applied to the track rails and, likewise, no voltage induced in windings 13 and 14 of the track transformer 10. Accordingly, there is no magnetomotive force produced by winding *b* of the track relay ATR. This condition would be represented in Fig. 2 by a point at origin 18. There is, however, a voltage induced in winding 17 of the auxiliary transformer 11, which voltage energizes winding *a* of the track relay to produce a magnetomotive force as indi-

cated by the reference character 20 in Fig. 2. Accordingly, the resultant or net magnetomotive force is indicated by the reference character 20. It is seen that this magnetomotive force is sufficient to energize the track relay to its reverse position.

The track relay remains energized in the reverse position until contact *a* of the code transmitter closes, at which time alternating current energy is supplied to the track rails. This energy flows along the track rails to the track transformer 10, assuming the track section to be unoccupied. This energy causes a voltage to appear across the primary winding 12 of the track transformer as illustrated by (+E), located along the positive abscissa axis in Fig. 2. This voltage causes voltages to be induced in the secondary windings 13 and 14. The voltage induced in winding 14 is rectified by rectifier K2 and the rectified current flows in winding *b* of the track relay. This current, in turn, produces a magnetomotive force as indicated by the reference character 29 in Fig. 2. Simultaneously, the voltage induced in the secondary winding 13 of track transformer 10 and the voltage induced in the secondary winding 17 of the auxiliary transformer 11 combine to produce a resultant voltage and the resultant voltage is rectified by rectifier K1. The rectified current energizes winding *a* of the track relay to produce a magnetomotive force as indicated by the reference character 30. The resultant magnetomotive force produced by the windings is represented by the reference character 31. It is seen that the resultant magnetomotive force is greater than the normal pickup value and, accordingly, the relay is energized to the normal position. Thus, as the track rails are supplied with coded current the track relay is alternately energized to the reverse position during the "off" period of the code and to the normal position during the "on" period of the code. The code following action of the track relay causes the movable member 4 to periodically make contact with fixed contacts 5 and 6 which, in turn, control the track signals to display, as discussed above, a green or proceed indication for traffic arriving at the entrance of the track section.

When the track section is occupied by a vehicle, the track rails are shunted which prevents the flow of energy from the supply end of the track section to the track transformer 10. Insofar as the track relay is concerned, this corresponds to the condition, discussed above, in which contact *a* of the code transmitter is open and, accordingly, the track relay is energized to the reverse pick-up position as indicated by the reference character 20. The relay remains energized in this manner as long as the track section is occupied. Since the track relay is not responding to code during this time, the relays AFSA and ABSA are deenergized and a red or stop signal is displayed to traffic approaching the track section.

Having thus described the normal operation of the track circuit embodying my invention, I shall now consider the case in which a current of the opposite relative polarity to that normally applied to the track rails flows across a defective insulated rail joint from an adjoining track section for the purpose of illustrating the inoperativeness of the track relay in response to currents of such polarity.

Let it be assumed that an insulated rail joint separating track section A from an adjoining track section such, for example, as the track section to the left of track section A is defective and simultaneously track section A is shunted by a vehicle. This causes the track section to be supplied with a current of opposite relative polarity to that normally supplied to the section. In this case, the voltage impressed upon the primary winding 12 of the track transformer 10 is of the reversed relative polarity to that considered above in connection with the normal operation of the track circuit. This is shown in Fig. 2 by the reference character (-E) located along the negative abscissa axis. The negative value merely indicates that this voltage is opposite in relative polarity to the voltage normally ap-

plied to this winding. Accordingly, the voltages induced in the secondary windings are reversed in phase to those normally induced in the windings. Since rectifier K2 is not phase sensitive, the reverse polarity has no effect upon the magnetomotive force produced by winding *b* of the track relay ATR, as shown by the reference character 32 of Fig. 2. However, the reversed phase causes the voltage induced in winding 13 of the track transformer 10 to be in phase with that induced in the secondary winding 17 of transformer 11. Thus, the magnitude of the voltage applied to rectifier K1 and winding *a* of the track relay increases, rather than decreases as discussed above in connection with the normal polarity. This causes a much larger magnetomotive force to be produced by winding *a* of the track relay as shown by the reference character 33. The magnetomotive force produced by winding *b* is represented by the reference character 32 and the resultant magnetomotive force produced by the windings is shown by the reference character 38. Thus, it is seen that the net result magnetomotive force is such to maintain the track relay in the reverse position. Therefore, it is in this manner that the relay, and thus the track signals, do not respond to coded current supplied from an adjoining track section across a defective insulated rail joint.

At this point it should be noted that there is no fault which can occur within the track circuit apparatus which, in connection with a defective insulated rail joint, can cause improper operation of the track relay and, in turn, the track signals. This fail safe feature is extremely important in connections with the use of track circuits in connection with signaling systems of the type in which my invention is intended to be used.

Often there are currents, other than signaling currents, which flow within the track rails. These currents, referred to hereinafter as foreign currents are caused by a variety of sources such, for example, as traction current for vehicles in electrified territory or earth currents from commercial power stations and the like. In such cases these foreign currents may develop sufficient voltage across the track rails at the relay end of the track section to cause improper operation of the track signals. It is, therefore, frequently necessary to provide the track circuit apparatus with means for preventing the foreign currents from affecting the track signals. My invention may be employed in connection with such means as shown in Fig. 3.

Referring now to Fig. 3, there is shown a track circuit embodying my invention which is provided with filtering means for preventing such foreign currents from affecting the track signals. Except for the filtering means, the operation of the track circuit is similar to that considered above in connection with Fig. 1 and, for that reason, the operation will not be redescribed here except where necessary in pointing out the operation of the filtering apparatus.

The filtering apparatus comprises a frequency selective network which is connected between the track rails and the phase selective network. The filtering means, as here shown, comprises a transformer 34 provided with a primary winding 35 connected to the track rails and a secondary winding 36. The secondary winding is connected in shunt with a capacitor 37 and the parallel combination is tuned to the signaling current frequency. A portion of the secondary winding is connected through a second capacitor 38 to a primary winding 39 of a second transformer 40. The second capacitor is tuned with the effective inductance of windings 36 and 39 to the signaling current frequency. Inasmuch as these circuits are tuned to the signaling current frequency, currents of this frequency are passed with little or no attenuation, but foreign currents having frequencies substantially different from that of the signaling current frequency are attenuated.

The transformer 40 is provided with a secondary winding 41 which is connected in a series opposing relation-

ship with winding 17 of the auxiliary transformer 11. The resulting voltage induced in these windings energizes the rectifier K1 and winding *a* of the track relay ATR as described above in connection with Fig. 1. Rectifier K2 and winding *b* of the track relay are energized by the voltage developed across a portion of the primary winding which is connected to the relay in an autotransformer relationship, rather than from a separate winding located on a track transformer as shown in Fig. 1.

It is to be noted that alternating current energy is supplied to the track rails from the transformer AT through an impedance 42 rather than through a resistance as shown in connection with Fig. 1. The impedance is used here not only to limit the current flowing through the secondary winding 8 of the transformer when the track rails are shunted by a vehicle, but also to produce a phase shift in the current applied to the track section to compensate for the phase shift produced by the filtering network as used in connection with the relay end of the track section. It is seen that this phase shift is necessary so that the voltages induced into the secondary winding of the track transformer and the secondary winding of the auxiliary transformer are in an opposing phase relationship as described above.

Another form of track circuit embodying my invention which may be used in connection with an alternating current track circuit is shown in Fig. 4. Insofar as the track signals are concerned, the operation of the track circuit is similar to that discussed above in connection with Fig. 1. The differences between the circuits lies entirely within the phase sensitive apparatus. In the circuits, here shown, both windings of the track relay are normally biased with a magnetomotive force, even when no energy is applied to the track rails.

A track transformer 43 is provided with two secondary windings 45 and 46 and with a primary winding 44 which is connected to the track rails. The secondary windings are, preferably, provided with the same number of turns. An auxiliary transformer 47 is provided with a primary winding 48 which is connected through resistance 16 to the source of energy 58. The auxiliary transformer is further provided with two secondary windings 49 and 50 of which one winding, here shown as winding 49, is provided with more turns than the other. Winding 45 of transformer 43 and winding 49 of transformer 47 are connected in a series opposing relationship, through the rectifier K1 to winding *a* of the track relay ATR while winding 46 of transformer 43 and winding 50 of transformer 47 are connected, in a series aiding relationship, through the rectifier K2 to winding *b* of the track relay. Resistance 16 in series with the primary winding 48 of transformer 47 merely provides means for adjusting the relative phase of the voltage induced in the secondary windings of transformer 47 with respect to those induced in the secondary windings of transformer 43. This phase shift compensates for the shift in phase of the current along the track section due to the track impedance, as discussed above.

Reference is made to Fig. 5 for an understanding of the mode of operation of the phase sensitive apparatus shown in connection with Fig. 4. It can be seen that this diagram is very much similar to that of Fig. 2 except for the differences discussed below.

It is to be noted that there is a magnetomotive force produced by each of the windings of the track relay when there is no voltage applied to the rails of the section. The magnetomotive force produced by winding *a*, when there is no track voltage, is represented by the reference character 52 whereas that produced by winding *b* is represented by the reference character 51. The resultant magnetomotive force of both windings as represented by the reference character 53 is such to energize the track relay to the reverse position. Thus, the track relay is maintained in the reverse position at times when

either contact *a* of the code transmitter is open or when the track rails are shunted by a vehicle.

During periods when contact *a* of the code transmitter is closed, a voltage represented by (+E) appears at the relay end of the track section, assuming the track section to be unoccupied. This causes a voltage to be induced in the secondary windings of the track transformer 43. This voltage, being of normal relative polarity, induces voltages of such polarity that winding *b* of the relay is provided with an increased magnetomotive force as represented by the reference character 29 and winding *a* is provided with a reduced magnetomotive force as represented by the reference character 30. Under these conditions, it is seen that the resultant or net magnetomotive force as represented by the reference character 31 is such to energize the track relay to the normal position. Thus, as long as the track rails are supplied with coded current, the track relay will alternately be energized to the reverse and normal positions. The slow releasing relays AFSA and ABSA are responsive to this action, as described above, to cause a green or proceed signal to be displayed to traffic approaching the track section.

At times when the track rails are shunted by a vehicle, there is no voltage induced in the secondary winding of the track transformer 43. Insofar as the phase sensitive apparatus is concerned, this provides an identical magnetization of the track relay as exists when the track section is unoccupied and contact *a* of the code transmitter is open. That is, the relay is energized with a magnetomotive force as indicated by the reference character 53 in Fig. 5 and is sustained in that position as long as the track rails are shunted by a vehicle. Accordingly, the relays AFSA and ABSA are deenergized and a red or stop signal is displayed to traffic approaching the track section.

Again, for the purpose of providing an understanding of the manner in which this track circuit functions in protecting the track relay and signals against the effects of a defective insulated rail joint, let it be assumed that one of the insulated rail joints to the left of the track section A is defective and that, simultaneously, a vehicle is occupying track section A. Energy from the track section to the left of track section A may flow across the defective insulated joint, as discussed above, to energize the track transformer 43. Since the adjoining track section is supplied with current of the reverse relative polarity, that is opposite to that normally applied to the transformer, this may be represented in Fig. 5 by the reference character (-E) located along the negative abscissa axis. In this case the voltage induced in winding 46 of transformer 43 and winding 50 of transformer 47 are substantially 180° out of phase and the magnetomotive force produced by winding *b* of the track relay is reduced as represented by the reference character 32 in Fig. 5. Similarly, the voltages induced in winding 45 of transformer 43 and winding 49 of transformer 47 are substantially in phase to increase the magnetomotive force produced by winding *a* of the track relay to that represented by the reference character 33. Thereby, the resultant magnetomotive force, as represented by the reference character 38, remains in the reverse pick-up region. Accordingly, as coded current is supplied over a defective rail joint, the resultant magnetomotive force merely alternates between the values indicated by the reference characters 38 and 53 which are both in the reverse pick-up region. Thus, the relay will not follow coded current of this relative polarity and the track signals display a stop or red signal to traffic arriving at the entrance end of the track section.

It should be understood that the track circuit shown in Fig. 4 may be provided with a filter network connected between the phase sensitive apparatus and the track rails to prevent foreign currents which may be

flowing within the track rails from effecting the track signals. In cases where a filter network is employed it may be desirable to use an impedance at the feed end of the track circuit to limit the flow of current rather than the resistance as discussed previously.

It may, at times, be desirable to employ a single winding relay in connection with track circuits of this type. My invention may be employed with such relays as illustrated in Fig. 6. Referring now to Fig. 6 it is seen that the circuit arrangement is similar to that shown and discussed in connection with Fig. 4, except for the connections between the track relay 54, which is a single winding relay, and the rectifiers K1 and K2. For the purpose of illustration, assume that the top terminal of each of the rectifiers is positive with respect to the bottom terminal as indicated by the polarity markings on the drawings. The positive terminal of rectifier K1 is connected to the negative terminal of rectifier K2 through two resistances 55 and 56, connected in a series arrangement. The common junction of the two resistances is connected to one end of the relay winding. The negative terminal of rectifier K1 and the positive terminal of rectifier K2 are connected together and, in turn, connected to the other end of the relay winding. Thus, the relay is energized with a polarity depending upon which rectifier is supplying the greater rectified voltage. At times when contact *a* of the code transmitter is open, rectifier K1 supplies the greater rectified voltage to energize the relay with one polarity since winding 49 of transformer 47 is provided with more turns than winding 50 and, accordingly, produces a larger induced voltage. However, when contact *a* of the code transmitter is closed, voltages are induced in the secondary windings of transformer 43, assuming the track section to be unoccupied, such that the voltage induced in winding 45 opposes the voltage induced in winding 49 and the voltage induced in winding 46 aids the voltage induced in winding 50. This causes rectifier K2 to supply the greater rectified voltage to the relay so that the track relay will be energized with the current of the opposite polarity. Thus a single winding relay may be employed in connection with my invention.

While I have described my invention as used in connection with coded track circuits, it should be understood that the same track circuit arrangement may be employed in connection with non-coded signaling systems. Moreover, while the drawings have shown the track section to be equipped with impedance bonds for electrified territory it should be understood that the apparatus may be used, equally as well, in non-electrified territory where impedance bonds are not employed.

While I have shown and described several forms of track circuits for a railway signaling system which embody my invention, it should be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In a railway signaling system for a stretch of railway track in which the track rails are divided into sections by insulated rail joints, a coded track circuit for each track section comprising, in combination, a source of alternating current energy, coding means connecting said source and said rails at one end of each track section for supplying coded current thereto, a relay, a first transformer provided with first and second secondary circuit means and with a primary circuit means connected to said rails at the opposite end of said track section, a second transformer provided with a secondary circuit means and with a primary circuit means connected to said energy source, said first secondary circuit means of said first transformer being connected in series opposition with said secondary circuit means of said second transformer, a first rectifying means connecting said series connected secondary circuit means to said relay, a second rectifying means connecting

said second secondary circuit means of said first transformer to said relay, and means controlled by said relay for indicating the occupancy condition of said track section.

2. In a railway signaling system for a stretch of railway track in which the track rails are divided into track sections by insulated rail joints, a coded track circuit for each track section comprising, in combination, a source of alternating current energy, coding means connecting said source and said track rails at one end of each track section for applying coded current thereto, a first transformer provided with first and second secondary windings and with a primary winding connected to the track rails at the opposite end of said track section, a second transformer provided with first and second secondary windings and with a primary winding connected to said energy source, said first secondary windings being connected in a series aiding relationship and said second secondary windings being connected in a series opposing relationship, a relay, rectifying means connecting said second secondary windings to said relay, and means controlled by said relay for indicating the occupancy condition of said track section.

3. In a railway signaling system for a stretch of railway track in which the track rails are divided into track sections by insulated rail joints, a coded track circuit for each track section comprising, in combination, a source of alternating current energy, coding means connecting said source and said track rails at one end of each section for applying coded current thereto and with adjoining sections supplied with currents of opposite relative polarity, a first transformer provided with a primary circuit means connected to the opposite end of said track section and with first and second secondary circuit means, a second transformer provided with a primary circuit means connected to said energy source and with a secondary circuit means, said first secondary circuit means of said first transformer being connected in a series opposing relationship with said secondary circuit means of said second transformer, a relay, a first rectifying means connecting said series connected secondary circuit means to said relay, a second rectifying means connecting said secondary circuit means of said first transformer to said relay, and signaling means controlled by said relay for indicating the occupancy condition of said track section.

4. In a railway signaling system for a stretch of railway track in which the track rails are divided into sections by insulated rail joints, a coded track circuit for each track section comprising, in combination, a source of alternating current energy, coding means connecting said source and said rails at one end of each track section for supplying coded current thereto, a relay, filtering means connected to the track rails at the opposite end of said track section, a first transformer provided with a primary winding connected to said filtering means and with first and second secondary windings, a second transformer provided with a primary winding connected to said energy source and with a secondary winding, said first secondary winding of said first transformer being connected in series opposition with said secondary winding of said second transformer, a first rectifying means connecting said series connected secondary windings to said relay, a second rectifying means connecting said second secondary winding of said first transformer to said relay, and means controlled by said relay for indicating the occupancy condition of said track section.

5. In a railway signaling system for a stretch of railway track in which the track rails are divided into sections by insulated rail joints, a coded track circuit for each track section comprising, in combination, a source of alternating current energy connected to one end of each track section, a relay, a first transformer provided with first and second secondary circuit means and with a primary circuit means connected to said rails at the opposite end of said track section, a second transformer provided with a primary circuit means connected to said energy source and

with a secondary circuit means, said first secondary circuit means of said first transformer being connected in series opposition with said secondary circuit means of said second transformer, a first rectifying means connecting said series connected secondary circuit means to said relay, a second rectifying means connecting said secondary circuit means of said first transformer to said relay, and means controlled by said relay for indicating the occupancy condition of said track section.

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